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Stress Studies in Composites Using Microdiffraction

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Introduction: The mechanical behavior of composites is controlled by interactions between fibers and the matrix [1]. Here, residual stresses play a crucial role as they influence these interactions. Microdiffraction provides a unique opportunity to study residual stresses on a scale similar to that of the microstructure allowing a better understanding of the deformation mechanisms.

Methods and Materials: A Ti-matrix/SiC-fiber composite [2] and a single fiber Al/Al_2O_3 composite [3] were investigated as model systems using X-ray microdiffraction [4]. Experiments included residual strain measurements on individual grains [2] as well as microtopography to study fiber/matrix interfaces [3].

Results: Fig. 1 shows the individual Ti grains that were correctly oriented for diffraction. This result confirms the high selectivity of diffraction yielding results from discontinuous regions in materials. The residual strains in the Ti matrix showed large variations from grain to grain. This suggests strong intergranular strains, typical in anisotropic materials such as Ti. A comparison of residual strain data obtained from deeper regions in the same composite [2,5] also indicated large strain gradients across specimen thickness.

The fiber/matrix interface in the Al/ Al_2O_3 composite was studied with microtopography. Fig. 2 shows the plot of the (201) reflection from alumina along fiber axis as the fiber enters the matrix. The high intensity observed on the left side is due to the shear strains in the single-crystal fiber resulting from the dynamic-to-kinematical transition of the reflection. By studying the change of this intensity over a large area of the interface we were able to identify buried holes and other defects at the interface. Knowledge about the size and location of such defects is important for understanding its structure, and ultimately, the mechanical behavior of the composite.

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